IRISH FISHERIES INVESTIGATIONS

SERIES B (Marine)

No. 6

(1969)

AN ROINN TALMHAIOCHTA AGUS IASCAIGH
(Department of Agriculture and Fisheries)

FO-ROINN IASCAIGH (Fisheries Division)

DUBLIN:
PUBLISHED BY THE STATIONERY OFFICE

TO BE PURCHASED FROM THE
GOVERNMENT PUBLICATIONS SALE OFFICE, G.P.O. ARCADE,
DUBLIN.

PRICE: *One shilling and sixpence.*

A REVIEW OF THE DUNMORE EAST HERRING FISHERY (1962—1968)

by

J. Molloy

INTRODUCTION : The winter herring fishery off the south coast of Ireland, based on what is commonly called the Dunmore stock, has been studied in detail by earlier workers and particularly by Bracken and Burd (1965). In their paper they reviewed the fishery up to 1963 and arrived at conclusions regarding the economic yield of the fishery. They stated that, "with the major spawning grounds (where the intense fishery takes place) situated within Irish exclusive fishery limits, there is considerable scope for the control of effort in such a way that, for the first time, a herring stock might be rationally exploited". Since 1963 certain changes have taken place in respect of the stocks themselves and the fishing to which they are subjected. The purpose of this paper is to bring these changes to light and to compare the state of the fishery during the seasons 1962/63 to 1967/68 with that during the period of Bracken's and Burd's observations. The Dunmore stock, which is fished mainly by Irish, Dutch and to a lesser extent French, German and Northern Irish boats, has varied considerably in its yield over the last fifteen years. The seasonal catch since 1956 taken off the south coast of Ireland by all boats taking part in the fishery and the total taken by Irish boats only are shown in Fig. 1. During this

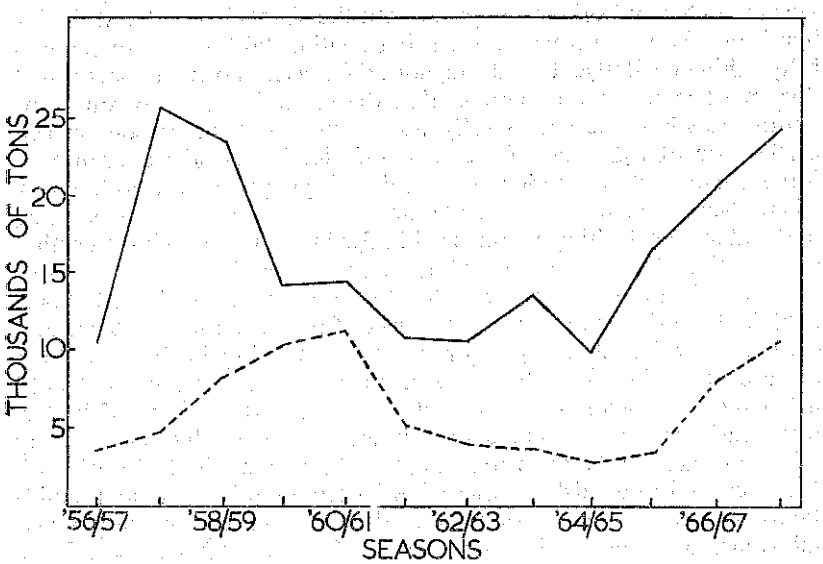

Fig. 1. Total catch taken from fishery

Total catch taken by Irish boats (broken line).

period the Irish Government has twice extended the exclusive fishery limits, in January, 1960, and again in January, 1966. On both these occasions the intensity of fishing by foreign fleets was affected to varying degrees and the present position is that boats of other than traditional fishing nations in this area are excluded from fishing within six miles of the base lines. Traditional nations, i.e. Holland, France, Britain, Belgium, Western Germany and Spain, were allowed to fish from 3 to 6 miles off shore until January, 1967, after which they were obliged to observe the six-mile limit. As the continental catches have a large bearing on the state of stocks it is important to understand how the fishery limits affect the annual yield.

LOCATION AND EXTENT OF FISHERY BY IRISH BOATS SINCE 1964

Irish fleet. The location and extent of the fishery as pursued by Irish boats has been described for previous seasons (Bracken 1963-1964) and Molloy (1965-1967). As the pattern of fishing has changed considerably over the last four seasons it is worth while reviewing these recent years. The 1964/65 season began late and it was not until mid-November that shoals were located south of Dunmore East in 39 metres. No large-scale landing were made until after Christmas when herrings had moved into the spawning grounds in Baginbun Bay. (See Fig. 2 for places mentioned in this paper). In February some small landings were again made south of Dunmore East in 55 to 59 metres. During 1965/66 the fishing again commenced late and at the end of November shoals were located off Ballycotton and Youghal, a little to the north, but these yielded poor catches and, as in the previous season, no heavy fishing took place until the shoals had entered Baginbun Bay. Although it was known that continental boats were successfully fishing off Ballycotton throughout the season, no Irish boats fished this area because it was thought that the grounds were too rough for bottom trawls to be successfully used. The 1966/67 season opened earlier, towards the end of October, off Helvick Head (just north of Mine Head) but the major effort quickly spread to Ballycotton Bay where heavy catches were made until mid-January by boats using mid-water gear. Fishing commenced in Baginbun Bay in mid-December and continued until the end of January. The 1966/67 season was notable for the fact that it was the first season in which Irish boats exploited the Ballycotton area and successfully fished mid-water trawls on the spawning stock in Baginbun Bay. Fishing in 1967/68 took place over a wide area. The season opened in mid-October but until mid-November boats were confined to fishing in the estuary of Waterford Harbour. In late November, however, catches by vessels using mid-water gear were made from around the Daunt Lightship off Cork Harbour and good fishing was experienced in this area up to mid-February, 1968. Good fishing was also experienced by bottom and mid-water boats fishing in Baginbun Bay from early November. Thus in the last four seasons considerable changes have taken place in the areas fished by Irish boats alone and two new grounds, which had not been previously exploited, have been successfully opened up. During

the period from 1958 to 1964 boats of the Irish fleet confined themselves to the traditional fishing grounds off Helvick, in the estuary of Waterford Harbour and in Baginbun but, after the poor fishing seasons from 1963 to 1966, and with the increase in use of mid-water gear and larger boats, the fleet was forced to exploit new areas.

Tin tow net cruises made by the research boat *Cú Feasa* during 1960/61 and 1961/62 had revealed considerable numbers of herring larvae west of the Daunt Lightship and it was concluded that spawning grounds must exist in this area. During July, 1966 the British research vessel *Ernest Holt* undertook a research cruise off the south coast of Ireland and located considerable quantities of herrings over an area extending from the Smalls to Mine Head, and also on the Labadie Bank. These were presumed to belong to the main winter spawning stock that frequent the south coast of Ireland. No fishing has been undertaken on these herrings by Irish boats.

Continental fleets. The main continental catches were made by Dutch boats fishing, prior to 1966, over a large area along the south coast of Ireland during October to January. However, during 1966 and 1967, the Dutch fleet started fishing much earlier than usual and took substantial amounts of herrings close to the Irish coast from July to October. Fig. 2 shows the statistical rectangles on the south coast of Ireland and the major fishing areas. In 1964/65 the Dutch fleet started fishing in October and from October to January their heaviest catches were taken in squares 02-21, 02-20 (October); 02-21, 01-20 (November); 02-22, 03-21, 02-21 (December); and 03-22 (January). In 1965/66 the

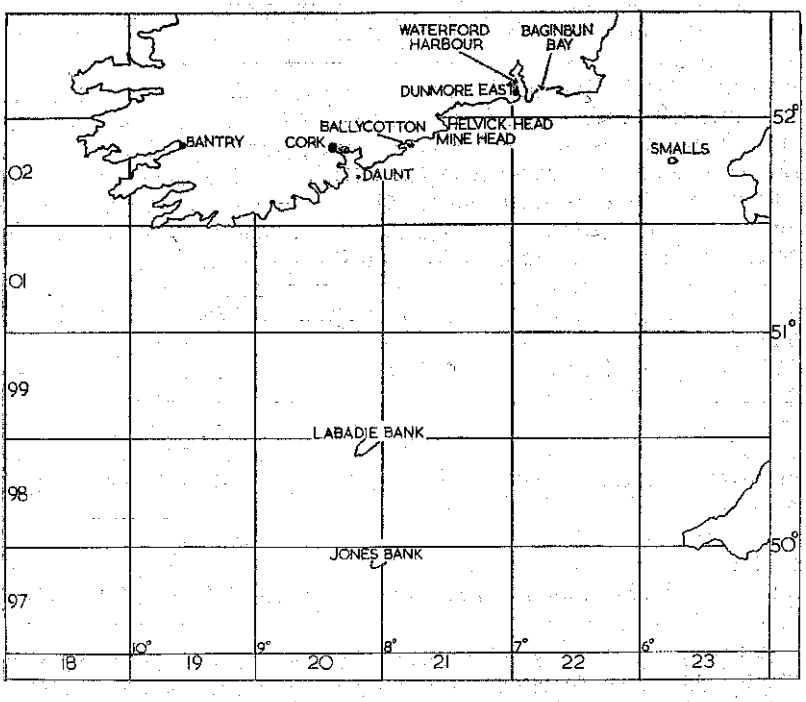

Fig. 2. Statistical rectangles and areas referred to in text.

overall picture was somewhat similar with heaviest catches in 01-22, 02-20, 02-21 ((October); 02-21, 01-22, 01-20 (November); 01-22, 02-21 (December); 02-21 (January); and 01-22, 02-21 and 02-20 (February). Fishing by Dutch boats commenced in July, 1966 and heaviest catches were made during 1966/67 in 01-20 (August); 01-21, 01-20 and 02-22 (September); 99-22, 01-21, 01-22, 98-21 (October); 01-20,01-22, 02-21, 99-21 (November); 02-21 and 01-20 (December). Fishing during 1967/68 again commenced in 01-21, 01-22, 99-22, 02-21 (July); and continued in 01-21, 01-22 (August); 99-20, 02-21, 01-22 (September); 02-21, 01-22, 99-20, 02-22 (October); 01-22, 99-20, and 01-20 (November) and 01-22, 02-21 and 02-20 (December).

From the limited statistics available from French sources it would appear that French boats fish mainly in the Smalls area and on the Labadie and Jones Banks during July to November.

COMPOSITION AND CATCH OF IRISH FLEET

The Irish fleet and its catch over the last four seasons has been as follows :

1964/65	24 boats	17,434 crans
1965/66	36 boats	20,542 crans
1966/67	50 boats	47,560 crans
1967/68	58 boats	63,343 crans

(5.93 crans = one metric ton)

As can be seen landings have risen considerably since the 1964/65 seasons. This increase can be attributed to three main factors (1) A greater abundance of herrings due to continued good recruitment, (2) A greater efficiency of boats, particularly the increased use of paired mid-water trawling and (3) Good weather during the 1966/67 and 1967/68 seasons. Landings per type of gear and the average catch per landing where available (in brackets) were as follows :

	1964/65	1965/66	1966/67	1967/68
Single Mid-water trawl	3,312	227	—	170
Paired mid-water trawl	2,586 (49.7)	2,956 (52.8)	27,870 (92.3)	38,893 (87.0)
Bottom trawl	11,536 (35.0)	17,359 (43.0)	19,690 (35.0)	24,280 (42.7)

All landings were made by boats using bottom or mid-water trawls. Single mid-water trawls have gradually given way to the more efficient paired method. The number of pairs engaged in mid-water trawling

has increased from three pairs in 1964/65 to twenty two pairs in 1967/68. Monthly landings shown below indicate an earlier start to the fishing during the last two seasons.

	1964/65	1965/66	1966/67	1967/68
October	7 crans	— crans	562 crans	1,002 crans
November	961 „	100 „	8,070 „	7,110 „
December	5,056 „	9,552 „	16,707 „	20,947 „
January	10,966 „	6,668 „	22,221 „	28,092 „
February	444 „	4,222 „	— „	6,192 „
TOTAL	17,434 „	20,542 „	47,560 „	63,343 „

CATCH, EFFORT AND CATCH/EFFORT

Catch, effort and catch per effort statistics are available from 1961 for the Irish, Dutch and Northern Irish fisheries. The German and Northern Irish fleets have altered very much in composition and catching power over the seasons since 1961. The German fleet no longer fish to the same extent as in the late "fifties" while the Northern Ireland fleet has been curtailed owing to considerable industrial disputes. In view of this neither set of catch/effort data may be realistic, —in particular the Northern Ireland landings at Milford Haven may be a combination of two boats' catches, transferred while at sea. The Dutch statistics come in the form of total catch per month, effort in terms of 100 fishing hours of a motor trawler 500 B.H.P., and the catch/effort is catch per 100 hours fishing. The Irish effort is in terms of number of landings and catch per landing and the Northern Ireland figures are number of arrivals and catch per landing at Milford Haven and include some other Irish landings as well. In order to eliminate the great differences between Irish boats of varying efficiency, the catch per landing figures have been smoothed in the following way. The total weekly catch and number of landings of all bottom and mid-water trawls are taken and the mean weekly catch per landing calculated. All boats whose weekly catch equals or exceeds this mean are termed *efficient* and their weekly catch per landing is thus estimated. This is related to the total catch per week for the corresponding type of gear and the weighted means of these catch per landing figures over a period are taken as the catch/effort. For bottom trawls this is estimated for the January/February period because it is during this time that herrings are on the bottom and are subjected to the greatest fishing effort. For mid-water trawls catch/effort has been estimated over the whole season. The Dutch effort has been calculated by multiplying the catch for each statistical rectangle by the catch per 100 hours fishing. The sum of these weighted means gives the effort for the season. Before examining each nation's statistics it is worth while commenting on the Dutch statistics from 1961/62 to 1967/68, which are shown in Table 1.

Table 1. Dutch Catch and effort figures

		61/62	62/63	63/64	64/65	65/66	66/67	67/68	68/69
Total Catch	July						72.4	2445.5	3785
Effort							4.2	139.7	149.2
catch/effort							17.2	17.5	25.4
Total Catch	August	66.8	124.9				320.3	711.2	1521
Effort		1.7	5.2				11.6	53.1	108.9
catch/effort		39.3	24.2				27.6	13.4	14.0
Total Catch	September	224.1	347.8				1810.0	1400.1	1953
Effort		3.7	7.2				42.6	51.5	108.7
catch/effort		60.6	48.2				42.5	27.2	18.0
Total Catch	October	649.0	1674.9	1971.1	723.2	2410.5	2438.7	2745.1	2005
Effort		22.7	79.5	52.0	31.0	57.8	103.3	132.6	103.3
catch/effort		28.6	21.1	37.2	23.3	41.7	23.6	20.7	20.2
Total Catch	November	633.3	433.1	833.2	1071.7	1707.3	3463.4	1620.2	2039
Effort		36.1	24.4	36.2	53.3	62.5	117.8	53.5	98.1
catch/effort		17.5	17.8	23.0	20.1	27.3	29.4	30.3	20.8
Total Catch	December	860.8	258.1	1745.4	1671.4	1759.6	1215.6	1283.8	790
Effort		5.6	12.1	30.0	45.8	42.8	61.4	55.1	39.5
catch/effort		154.0	21.4	58.1	36.5	41.1	19.8	23.3	20.0
Total Catch	January	846.4	3538.7	1755.5	274.3	2964.5	325.8		∞
Effort		4.7	32.0	42.5	9.4	20.4	19.4		
catch/effort		180.1	110.6	41.3	29.2	145.3	16.8		
Total Catch	February	0.1	286.9		110.1	1926.1	3.2		
Effort		1.3	6.2		1.7	37.4	0.4		
catch/effort		0.1	46.2		63.4	51.5	8.5		
Total Catch	March					4.1			
Effort						2.6			
catch/effort						1.6			
Total Catch	April		9.1						
Effort			1.5						
catch/effort			6.0						
TOTAL									
Total Catch		3280.5	6673.5	6305.2	3850.7	10772.1	9649.4	10205.8	12,163
Effort		75.8	168.1	160.7	141.2	223.5	360.7	485.5	615.2
catch/effort		43.3	39.7	39.2	27.3	48.2	26.8	21.0	19.9

Catch in metric tons.
Effort in 100 fishing hours of a motor-trawler 500 B.H.P.
Catch per effort in tons per 100 hours fishing.

These are given in monthly catches (metric tons), effort, and catch per effort. As can be seen, the Dutch catch which had fallen off following the heavy fishing during 1957/58 and 1958/59 and the subsequent extension of Irish territorial waters, has again started to rise and during the seasons from 1965 onwards has remained fairly constant at approximately 10,000 tons. This rise in total catch has been accompanied by a very great increase in effort particularly over the three seasons, 1965/66, 1966/67, 1967/68. The catch per effort, on the other hand, has remained fairly constant from 1961/62 to 1965/66, apart from a drop in 1964/65, but has shown a marked decrease during 1966/67 and 1967/68. This would suggest that boats of the Dutch fleet, in order to counteract the effect of the further extension of the limits in January, 1966 and maintain their catch, have in fact increased their effort, by starting to fish as early as July and at the same time suffer considerable drop in their catch per effort. During 1967/68 approximately half their effort was expended from July to the beginning of October, before the Irish fleet had commenced herring fishing at all in this area. In Table 2 the catch per effort statistics for the various countries per type of gear are shown.

Table 2. Catch/effort figures for various fleets.

	Irish		Dutch	German		Northern Irish
	Crans per landing		Tons/100 hrs.	Tons/10 day fishing		Crans/landing
	Efficient bottom trawl	Efficient mid-water trawl	Trawl	Herring Trawl	Pelagic Trawl	Trawl
1961/62	44.7	—	43.3	—	—	21.5
1962/63	72.6	—	39.7	25.0	—	65.0
1963/64	56.4	—	39.2	22.0	—	57.8
1964/65	77.1	126.2	27.3	—	—	55.5
1965/66	68.7	93.1	48.2	38.0	78.0	64.2
1966/67	74.2	171.8	26.8	14.0	22.0	83.7
1967/68	79.2	173.7	21.0	31.0	29.0	82.1

Since the 1965/66 season Irish boats using bottom trawls and mid-water trawls have worked together successfully throughout the season. By taking these efficient vessels for both sets of gear and plotting the

corresponding weekly catches it was hoped that a significant regression would emerge. However, no significance was obtained and so it was not possible to estimate any annual abundance indices in this manner. Therefore, to obtain an estimate of total effort, only the catch per effort statistics of the two main participants in the fishery, viz. the Dutch and Irish fleets have been used. As the Irish catch per effort data are underestimated for 1967/68, due to the imposition of catch quotas, both sets of data have been smoothed and converted into the equivalent Dutch catch per effort figure, i.e. tons per 100 hours fishing. The method of smoothing and conversion is as follows.

The mean catch per effort from 1961/63 to 1967/68 was obtained for both sets of data. Each individual catch per effort statistic was then expressed as a ratio of this period mean, and these ratios again meaned for each season as shown below (Table 3).

Table 3. Conversion of catch per effort to smoothed Dutch equivalent

	Catch/Effort				
	Irish Tons/ landing	Dutch Tons/ 100 hrs.	Irish	Dutch	Mean
1961/62	7.54	43.3	0.68	1.23	0.96
1962/63	12.24	39.7	1.07	1.13	1.12
1963/64	9.51	39.2	0.86	1.12	0.98
1964/65	13.00	27.3	1.17	0.78	0.99
1965/66	11.59	48.2	1.05	1.37	1.21
1966/67	12.51	26.8	1.13	0.76	0.95
1967/68	—	21.0	—	0.60	0.60
Mean	11.06	35.07			

When these final means are multiplied by the mean catch per effort for the period, smoothed catches per effort are obtained. The Irish catches per effort are then converted into the equivalent Dutch data. This is obtained by taking the Irish 1961/62 catch per effort figure as standard and expressing the subsequent catch per effort figures as a ratio of this. These ratios, when multiplied by the Dutch catch per effort figures for 1961/62, give the equivalent Dutch catch per effort figures for the various seasons. The steps taken in obtaining these are given in Table 4.

Table 4. Smoothed catch per effort and total effort.

Season	Irish	Ratio	Dutch	Equivalent Dutch smoothed catch per effort	Total catch 1,000 metric tons	Total effort
1961/62	11	1.00	34	34.0	10.9	320.6
1962/63	12	1.09	39	37.1	10.7	288.4
1963/64	11	1.00	34	34.0	13.6	400.0
1964/65	11	1.00	35	34.0	9.7	285.3
1965/66	14	1,27	42	43.2	16.6	384.2
1966/67	11	1.00	33	34.0	20.8	611.8
1967/68	7	0.64	21	21.8	24.7	1133.0

When these catch per effort figures are divided into the corresponding total catch the total effort in 100 hours fishing is obtained. From this it can be seen that since 1961 the effort remained fairly constant up to 1965/66 but since then it has risen rapidly. This rise in effort has been accompanied by a significant increase in total catch, which has now more than doubled over the five seasons 1963/64 to 1967/68.

ESTIMATES OF INSTANTANEOUS TOTAL MORTALITY

Estimates of total mortality have been calculated from Irish and Dutch material. The stock abundance estimates used in these mortality calculations are based on (1) age composition in crans per landing of efficient bottom trawls per season and for the January to February period and for mid-water boats per season for 1967/68, (2) percentage age distribution multiplied by the Dutch catch per effort per season and for the month of December, and (3) percentage age distribution multiplied by the smoothed catch per effort obtained in Table 4. The age distribution in crans per landing of efficient bottom trawls is shown in Table 5.

Table 5. Age composition of herring catches landed at Dunmore East (in crans per efficient trawler landing)

Season	Age in Years										
	2	3	4	5	6	7	8	9	10	10+	Total
1963/64	0.57	30.34	5.49	2.52	8.90	1.27	0.57	1.12	0.69	0.63	52.10
1964/65	10.46	21.19	24.38	5.56	2.62	11.81	1.80	1.00	1.30	2.15	82.27
1965/66	1.98	34.92	8.91	10.33	3.89	3.81	7.10	1.10	0.38	1.79	74.21
1966/67	2.74	13.08	24.32	5.33	7.44	3.10	1.53	4.93	0.63	1.06	64.16
1967/68	7.00	32.89	10.28	14.83	3.68	3.24	0.87	1.99	0.84	0.64	76.26

Unfortunately the Dutch ceased biological sampling in this area for a period and estimates of mortality based on the Dutch catch per effort have been based on the percentage age distribution obtained from sampling at Dunmore East. Due to the many industrial disorders the catch per effort statistics used have resulted in a considerable amount of variation in the instantaneous mortality rates. The instantaneous mortality rates from the various sources have been meaned and are shown in Table 6.

Table 6. Instantaneous mortality rates.

	Age Groups						
	4/5	5/6	6/7	7/8	8/9	9/10	Mean
1961/62 1962/63	0.12	0.19	0.73	0.02	0.27	0.16	0.16
1962/63 1963/64	1.26	0.73	1.18	0.37	0.53	0.72	0.80
1963/64 1964/65	0.51	0.39	0.19	0.13	0.06	0.20	0.25
1964/65 1965/66	0.78	0.38	0.09	0.08	0.20	0.49	0.31
1965/66 1966/67	1.00	0.65	0.42	0.76	0.69	0.82	0.72
1966/67 1967/68	0.71	0.45	0.71	0.94	—0.16	1.80	0.74

It can be seen that, with the exception of the seasons 1962/63 and 1963/64, the mean instantaneous mortality has increased from 0.16 to 0.74 during 1961 to 1968. The high estimate from 1962 to 1964 was probably caused by over-sampling of young fish during the early part of the 1963/64 season.

When a regression of the total smoothed effort against the total mortality figures obtained from all the above-mentioned sources was plotted it proved significant ($p = 0.01$) and an estimate of natural mortality of 0.15 was obtained (Fig. 3). Using this regression equation ($y = 0.074x + 0.15$) total mortalities were recalculated for the period 1961-1968 and resulted as follows :

Seasons	Mean Effort (smoothed)	Total mortality (F)
1961-1963	305	0.38
1962-1964	344	0.40
1963-1965	343	0.40
1964-1966	335	0.40
1965-1967	498	0.52
1966-1968	872	0.80

These figures agree closely with those obtained by Bracken and Burd (1965). It can readily be seen that the Dunmore stock reacts very quickly to increased changes in effort and its survival is almost completely dependent on good recruitment.

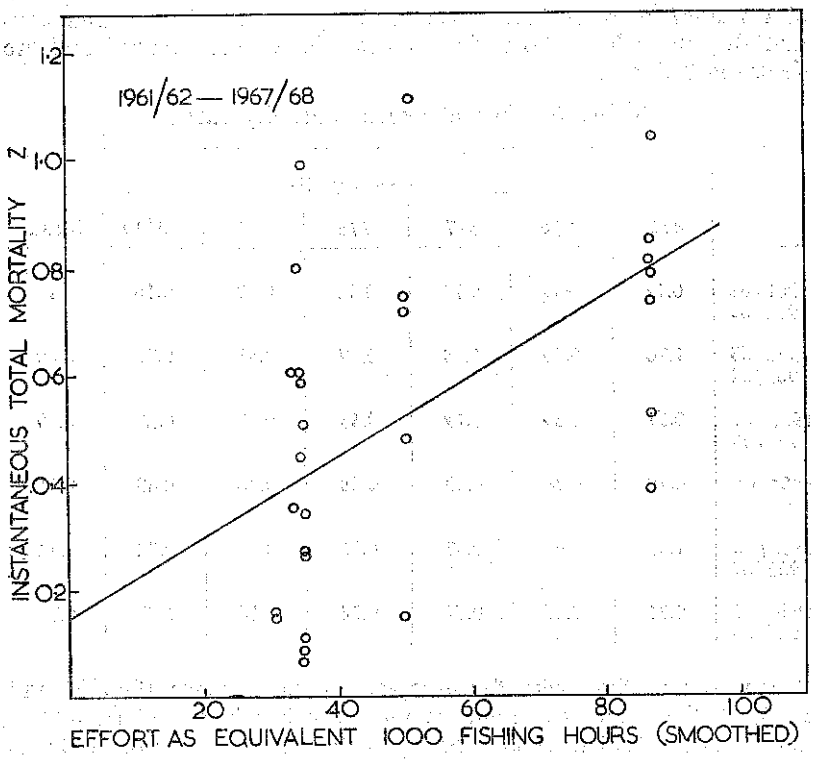

Fig. 3. Regression of total instantaneous mortality on smoothed effort.

AGE, GROWTH AND RECRUITMENT

Age distributions for the previous seasons have already been shown in Table 5. It is obvious that the fishery is based mainly on three, four and five year-old fish. Bracken and Burd (1965) have shown that recruitment to the Dunmore stock takes place over three age groups, two, three and four year-olds with the major recruitment at three years of age. Obviously the Dunmore fishery depends a great deal on the recruitment, failure of which for more than two seasons could cause excessive reduction of existing stocks. Estimates of recruitment, based on catches of efficient bottom trawls, in tons per landing for three year-old fish are shown below.

Season	Three year old Tons/landing
1963/64	5.12
1964/65	3.57
1965/66	5.89
1966/67	2.21
1967/68	5.55

It can be seen that recruitment has been fairly consistent over these seasons and, apart from the season 1966/67, has been satisfactory. The poor recruitment during 1966/67 shows up very well with the absence of four year-old fish during the season 1967/68. Owing to the fact that all fish caught during the seasons 1962/67 to 1967/68 were from trawlers and consequently lacked scales it is not possible to determine whether any change in the recruitment pattern has taken place, but it would seem from comparing the age distributions with those of Bracken and Burd (1965) that more two year-old fish are entering the stocks. This, together with the increased mean lengths per age class (mentioned below), would seem to suggest that fish are recruiting at an earlier age.

Reliable estimates of mean length per age-class are available for a number of sesaons. Bracken and Burd (1965) concluded that no apparent change in mean lengths appeared to have taken place over the years up to and including 1963. However, the mean lengths of the last four seasons compared with the previous data seem to show certain differences and the comparative figures are shown in Table 7.

Table 7. Mean lengths per age class.

Age in Years	1964-1968	1921-1963	Increase
	cm.	cm.	cm.
3	26.01	25.01	1.00
4	27.86	26.79	1.07
5	29.11	27.85	1.26
6	29.83	28.59	1.24
7	30.16	29.06	1.10
8	30.31	29.51	0.80
9	30.56	29.63	0.93
10	30.65	29.84	0.81

As can be seen the recent mean lengths show an average increase of 1.03 cms. per age class. The 1964 to 1968 means were taken and used to obtain the growth constants required in Von Bertalanffy's growth equation. The mean lengths for three year-olds have been disregarded as being, due to partial recruitment, unrepresentative of the population three year-old fish. The parameters of the growth curve obtained compared with the corresponding data for the previous observations were as follows :

	L_∞	W_∞	K	T_o
1921-1963	30.1	236.0 gms.	0.40	—1.51 years
1964-1968	30.9	286.0 gms.	0.53	—0.3501 years

When the t_o was estimated for each age group the resulting estimates proved highly variable and gave a mean estimate of +0.17 years. A more realistic value was obtained by excluding the older and highly variable age groups. This gave an estimate of $t_o = -0.3501$ which, when used to obtain mean lengths per age class, gave estimates very close to the original values.

This data would again suggest a more rapid increase in growth and a difference in spawning time. An earlier spawning or a more prolonged spawning period would affect the value of t_o and bring it near to the expected origin.

ESTIMATION OF MAXIMUM SUSTAINABLE YIELD

An estimate of the maximum sustainable yield for the Dunmore herring stock was derived using the tables of yield functions by Beverton and Holt (1966). The parameters (E, C and M/K) used in the modified form of the yield equation were based on the following data: $L_\infty = 30.9$ cms, Lc = 25.99 cms (the mean length of three year herrings) F = .65, M = 0.15) and K = .53. It would appear from the tables that the maximum sustainable yield would be in the region of 22.0 thousand tons compared with the 1967/68 total catch of 24.7 thousand metric tons. This estimate assumes, naturally, that recruitment remains constant and would be achieved when z = .60. In comparison with the earlier maximum sustainable yield estimated by Bracken and Burd (1965) of 15.0 thousand metric tons it would appear that the relatively low catches taken in the 1961-1964 period have enabled the stocks to recuperate to the extent that the economic level of fishing has been raised by approximately one-fifth or, alternatively, that differences of this order in the maximum sustainable yield may arise because recruitment is not constant and the area of exploitation has been increased. However, it would seem probable that the fishery would not continue to yield catches of the present magnitude for any length of time.

MATURITY

The Irish south coast herring fishery is based on an inshore spawning stock so that naturally most fish are stage V early in the season, becoming stage VI as the season progresses. Quantities of immature fish are found earlier in the season but their prevalence seems to be determined more by the areas in which boats are fishing rather than abundance among the main shoals. Spent fish are rarely taken in quantity but are usually present in small numbers throughout the season. Since 1961 there seems to be a tendency for an earlier onset of spawning. Stage VI fish are now taken as early as mid-November and continue to be taken throughout the season until they are completely dominant in January and February. In Table 8 below the percentage distribution of stage V and VI per month is shown for the ten seasons from 1958/59 to 1967/68.

Table 8. Percentage distribution of stages V and VI

Season	V					VI				
	October	Nov.	Dec.	January	February	October	Nov.	Dec.	January	February
58/59	—	66.0	57.1	22.6	18.4	—	1.6	5.2	61.4	72.2
59/60	—	58.4	71.8	40.0	30.8	—	30.3	17.0	44.6	60.3
60/61	—	89.5	75.7	49.4	—	—	2.3	1.6	42.7	—
61/62	—	81.7	68.9	37.5	—	—	8.6	16.8	61.0	—
62/63	—	73.8	83.9	13.8	—	—	11.6	4.2	84.9	—
63/64	91.3	83.6	71.1	9.0	0.2	—	9.1	21.9	83.1	91.3
64/65	—	95.9	69.4	17.8	5.3	—	0.4	10.8	79.3	85.0
65/66	—	86.0	66.0	34.0	21.0	—	2.0	28.0	58.0	76.0
66/67	44.3	73.0	48.7	14.0	—	—	5.9	40.0	83.4	—
67/68	—	62.6	25.2	6.4	4.3	—	13.8	71.4	89.4	89.2

In the late nineteen "fifties" and early "sixties" there was a separate, although very small, autumn spawning component which was fished in Baginbun Bay during October and November. This component has not, however, been fished since 1961/62 and this accounts for the high proportion of stage VI in November during the earlier seasons. The tendency towards an earlier spawning is not particularly noticeable in November but there is evidence of an increase in stage VI fish and a slight decrease of stage V fish since 1964/65. In December these changes become more apparent—stage V fish having decreased from 83.9% in 1962/63 to 25.2% in 1967/68 while stage VI fish increased from 4.2% in 1962/63 to 71.4% in 1967/68. This change is maintained to an expected lesser degree in January which has always been considered the main spawning month. The evidence from sampling thus indicates spawning is tending to take place earlier each season. This would suggest that herring resulting from these earlier spawnings and recruiting at two and three years of age would be slightly larger and that potential recruits would be in a position to mature and enter the adult fishery at an earlier age than in previous years.

OTOLITHS AND NUCLEAR TYPE

Otoliths for the four seasons 1963/64 to 1967/68 have been examined and classified according to the type of first winter ring and nuclear type. The type of first winter ring is divided into two categories narrow (n) and wide (w). Unclassifiable types are denoted by (u). Foster (1964) has shown that the full range of nuclear types occur in samples from Dunmore East and suggests that this could be due to the prolonged spawning period from December to February. The overall distribution of otolith types has not changed since that time with the small hyaline type still dominating. The distribution (as percentages) of the first winter ring type for the last four seasons is shown in Table 9.

Table 9. First winter ring type.

	2	3	4	5	6	7	8	9	10	10+
	n w u	n w u	n w u	n w u	n w u	n w u	n w u	n w u	n w u	n w u
1964/65	70. 8.22	54.45. 1	74.25. 1	68.30. 2	68.29. 3	59.34. 7	76.20. 4	78.28. 2	84.13. 3	64.32. 4
1965/66	77.19. 4	73.25. 2	72.26. 2	85.13. 2	78.20. 2	79.19. 2	68.29. 3	90. 5. 5	80.13. 7	92. 8.—
1966/67	96. 2. 2	77.22. 1	82.17. 1	66.32. 2	89.10. 1	90.10. 0	90.10.—	80.16. 4	96. 4.—	92. 6. 2
1967/68	83. 8. 9	81.17. 2	70.26. 4	72.24. 4	66.31. 3	81.18. 2	67.30. 3	68.29. 3	79.19. 2	72.24. 4

Overall distribution	1964/65	66	29	5
	1965/66	75	23	2
	1966/67	83	16	1
	1967/68	77	20	3

VERTEBRAL COUNTS. Vertebral counts have remained constantly high and typical of a winter spawning stock. The overall counts for the four seasons were

1964/65	56.86
1965/66	56.93
1966/67	56.85
1967/68	56.92

The evidence of the otoliths and vertebral counts would suggest that the racial composition of the stock has not altered in the last few seasons, even thous the maturity data suggests the onset of earlier spawning. The vertebral counts of the fish spawning earlier in November and December all have the typically high winter spawning count.

SUMMARY

(1) The total catch of herring taken from what is commonly called the Dunmore East fishery has risen from a mean 10,200 tons (1961 to 1965) to a mean of 18,200 (1966 to 1968).

(2) This rise in total catch has been accompanied by, roughly, a two-fold rise in effort and subsequent increase in total mortality.

(3) The maximum sustainable yield has been estimated as 22,000 tons, assuming recruitment is constant.

(4) There is evidence to suggest that because of an earlier onset of spawning the recruiting pattern may be changing.

(5) There is no evidence to suggest that the question of unity of stocks may have altered, even though an earlier onset of spawning might suggest an intermingling of an autumn spawning stock.

REFERENCES

Beverton, R. J. H., and Holt, S. J., 1966. "Manual of methods for fish stock assessment—Part III Tables of Yield Functions". FAO. Fish .tech. Pap No. 38.

Burd, A. C., & Bracken, J., 1965. "Studies of the Dunmore Herring Stock. I.A. Population Assessment" *Jour. du Cons.* Vol. XXIX. No. 3.

Bracken, J., and Foster, M., 1963. "Herring Investigations at Dunmore East—1962/1963". ICES, C.M. 1963, Herring Comm. Doc. 110.

Bracken, J., 1964. "Report on Dunmore East Herring Fishery—1963/64". ICES, C.M. 1964, Herring Comm. Doc. 86.

Molloy, J. 1965. "Herring Investigations at Dunmore East—1964/65". ICES, C.M. 1965. Herring Comm. Doc. 80.

Molloy, J., 1966. "Herring Investigations at Dunmore East—1965/66". ICES, C.M. 1966. H: 5.

Molloy, J., 1967. "Herring Investigations on the South Coast of Ireland —1966/67". ICES, C.M. 1967, H: 7.

Department of Agriculture and Fisheries,

Fisheries Division,

Dublin 1.

(7265)N58614. 1,000. 10-69. F.P.—G3.